

"For Notable Scientific and Industrial Achievement in Electrical Engineering"

*1938 Faraday Medal of The Institution of Electrical Engineers, Great Britain,
presented to W. D. Coolidge at AIEE North Eastern District meeting*

THE FARADAY MEDAL, awarded for 1938 to W. D. Coolidge (A'10, M'24), was presented at the AIEE North Eastern District meeting, Springfield, Mass., May 4, 1939, by Gano Dunn (A'91, F'12) honorary secretary for the United States of The Institution of Electrical Engineers of Great Britain. The award was conferred by the council of the IEE at its meeting on January 16, 1939.

Highest honor of the IEE, the Faraday Medal was established in 1921 to commemorate the 50th anniversary of the society's first ordinary meeting. It is awarded not oftener than once a year for notable scientific or industrial achievement in electrical engineering or conspicuous service rendered to the advancement of electrical science, without restriction as to nationality, country of residence, or membership in the society. Seventeenth recipient of the award, Doctor Coolidge is the third American to receive it, the others being AIEE Past-Presidents Elihu Thomson and F. B. Jewett. Nine of the 17 recipients have been members of the AIEE.

W. D. Coolidge is director of the research laboratories of the General Electric Company, Schenectady, N. Y., and one of the world's foremost X-ray scientists. A biographical sketch of him appeared in the March issue (page 137). Full texts of the presentation address by Doctor Dunn and Doctor Coolidge's speech of acceptance follow.

Careers of Faraday and Coolidge

GANO DUNN, Fellow AIEE

It is unusual, and it increases the honor, when a medal comes to an American from the other side of the Atlantic, for that is evidence of a fame broader than our own national boundaries.

And to a British honor, there is a peculiar character that enhances its value, on account of our common background of political and scientific history, and community of language.

As the local honorary secretary for the United States of America of The Institution of Electrical Engineers of Great Britain, I am authorized by the president and council of the Institution to present the Faraday Medal to Doctor William David Coolidge of Schenectady, N. Y., in consummation of the award made to him on January 16, 1939, for notable scientific and industrial achievement in electrical engineering.

The Faraday Medal has previously been given to only two Americans, Elihu Thomson and Frank B. Jewett.

It is a medal founded in 1921 to commemorate the 50th Anniversary of The Institution of Electrical Engineers, the first ordinary meeting of which, under the name of the Society of Telegraph Engineers, was held in 1871, antedating the AIEE by 13 years.

The Institution of Electrical Engineers has nearly 18,000 members, a considerable number of whom are scattered over the earth throughout the British Dominions. The Faraday Medal is their principal honor, as is the Edison Medal in the AIEE.

In naming it after Michael Faraday, they chose a figure not only high in the world's record of great achievements, but high in the affections of scientists and engineers the world over; on this account the award is without restrictions as regards nationality, country of residence, or membership in the Institution.

Fascination of Faraday's Life

To every scientist and engineer, there is a fascination in the career of the blacksmith's son apprenticed to a bookbinder, who devoted every moment of his precious leisure to watching the demonstrations of Sir Humphrey Davy from the gallery of the Royal Institution of London, in which, after becoming Sir Humphrey's assistant and then lecturer, he became resident professor, and put the whole world in his debt by his marvelous discoveries.

Faraday is of the type of genius, geometrical rather than mathematical. He asked questions of Nature in the form of experimental presentations devised in the assumption of brilliant working hypotheses, with a flair and a genius for the suspicion of truth long before it became evident. His world was objective and his processes intuitive.

He was the first to infer and later to prove a connection between magnetism and light, and to draw attention to the medium as the seat of phenomena, and he was the first to infer and later to demonstrate not only electromagnetic induction but the possibility of generating electricity from mechanical motion, a discovery on which depends not only the whole power and light industry of today, but so many others that if the discovery were removed, civilization would stop.

A deeply religious man, he left in his character a record as laudable as in his work. I cite these meager facts about Faraday to indicate why The Institution of Electrical Engineers selected him as the exemplar for their principal honor, and why that honor is the highest in their gift to give.

There is for Americans an association with Faraday of

which they are proud. It gives to the advent of a Faraday Medal in the United States a measure of sentiment, for it is in part to a distinguished American scientist and administrator that the Royal Institution, which gave Faraday his opportunity and his platform, owes its existence.

That American was Benjamin Thompson of Rumford Falls, N. H. A member of the Royal Society, he was one of the promoters of the Royal Institution. When ennobled by the Emperor of Austria, he chose the title Count Rumford, under which his experimental determination of the mechanical equivalent of heat and much other valuable scientific work is known.

Benjamin Thompson's part in the founding of the Royal Institution has always been associated in my mind with a reciprocal remarkable gesture of large generosity by a distinguished British scientist, James Smithson, who willed his whole fortune, which was delivered over here in gold coin, to the President of the United States, and certain other officers of the United States Government, eternally to found the great Smithsonian Institution in Washington.

If we are told about the essayist on the life of the Duke of Wellington who gave three-quarters of his space to the great military genius of Napoleon, we must bear in mind that he did it in order the better to display the Duke of Wellington as the world's greatest victor's victor. This is my motive in describing at this length the prestige and honor that lie behind the Faraday Medal.

Medalist Coolidge's Achievements

It has been awarded to our William David Coolidge of the AIEE (and of so many other scientific and engineering organizations that it is difficult to enumerate them) because of the trail he blazed in the virgin territory of the Roentgen rays (by which name the British still designate what we call X rays) and because of his later great work in that and other fields.

Doctor Coolidge experimented with tungsten for incandescent-lamp filaments and devised the amalgam process for making such filaments.

As far back as 1912 and 1913, he used the results of investigations of Doctor Langmuir in electron emission from hot filaments and produced the Coolidge X-ray tube, which gave complete control of the intensity and penetrating power of the rays, continuous operation without change in intensity, and complete absence of fluorescence of the glass. This tube accommodated voltages up to 200,000 volts, with a corresponding intensity of the rays, and a capacity for revealing new knowledge in widely scattered fields, in which these high voltages were employed for research.

The Roster of Faraday Medalists

1922	Oliver Heaviside*
1923	Sir Charles A. Parsons
1924	S. Z. de Ferranti*
1925	Sir J. J. Thomson
1926	Colonel R. E. B. Crompton
1927	Elihu Thomson*
1928	Sir J. A. Fleming
1929	Guido Semenza*
1930	Lord Rutherford
1931	C. H. Merz*
1932	Sir Oliver Lodge
1933	Sir Frank E. Smith
1934	F. B. Jewett*
1935	Sir William Henry Bragg
1936	André Blondel*
1937	Sir John Snell*
1938	W. D. Coolidge*

* AIEE member

In 1917 Doctor Coolidge brought out a complete portable X-ray generating outfit for military service in the field. This included a specially developed radiator-type tube of large heat capacity which was destined to supplant the earlier type of hot-cathode tube for all diagnostic work.

In 1924 Doctor Coolidge finished developing his oil-immersed self-contained X-ray outfits, which could be safely manipulated without expert technique, and which had many applications in dentistry, in physical laboratories generally, and in industry.

In 1928 Doctor Coolidge determined and explained the cold-cathode effect which limits the voltage

that can be used on a given tube. For high voltages he developed a subdivided tube with intermediate tubular electrodes which accelerate the electrons at each stage, so giving an extremely high electron speed for bombardment of the final electrode. He predicted the use of this type of tube working on 2,000,000 volts, which would produce X rays as penetrating as the shortest wave-length gamma rays from radium.

In 1932 Doctor Coolidge presented a remarkable paper at the International Electrical Congress of Paris which put forward the results of his experiments on the "Behavior of Cathode Rays Outside the Generating Tube."

Recognition Awarded Coolidge

But these are not all his accomplishments. As assistant to Doctor Willis R. Whitney and later as director of research of the General Electric laboratory at Schenectady, N. Y., Doctor Coolidge's work in many fields, including that of ductile tungsten, has been outstanding. It has been recognized by the Edison Medal of the AIEE for his contributions to the incandescent electric-lighting and the X-ray arts, and by numerous other medals; in 1914 the Rumford Medal; in 1926 the Howard N. Potts Medal of the Franklin Institute of Pennsylvania and the Louis Edward Levy Gold Medal; in 1927 the Hughes Medal of the Royal Society of London, and the gold medal of the American College of Radiology; in 1932 the Washington Award of the Western Society of Engineers, and in 1937 the John Scott Medal and Award.

In addition to memberships in numerous scientific societies, he is an honorary member of the Roentgen Ray Society, the American Radium Society, the Radiological Society of North America, the American College of Radiology, the Roentgen Society (of England), the Société de Radiologie Médicale (of France), Nordisk Forening for Medicinsk Radiologi (of Scandinavia); and in 1927 he was awarded honorary degrees of doctor of science by Union College and by Lehigh University.

The Faraday Medal is like the laurel wreath of the

Greeks. It is of bronze rather than of gold, because it was particularly desired that there should be no suggestion of intrinsic value in the medal itself, but that it rather should owe its value, first, to the fact that it was instituted to commemorate the foundation of The Institution of Electrical Engineers, and, second, that it is offered for world-wide service to electrical science and electrical engineering.

In bestowing upon Doctor Coolidge the Faraday Medal, The Institution of Electrical Engineers is placing his name in a roster made illustrious by world-known names, to which roll of honor his name is a worthy addition.

Modern Developments From Faraday's Work

W. D. COOLIDGE, Member AIEE

I was sorry not to be able to go to England to receive this great honor directly from The Institution of Electrical Engineers. In some ways, however, it is not unfitting that I receive it through the kindly auspices of the AIEE, of which I have long been a member. Nor is it unfitting that I receive it in Springfield, Mass., for there are many factors connecting this locality with the event.

Benjamin Thompson was born in Woburn, Mass., only 86 miles from here, and he it was who, in 1796, formulated a plan which later resulted in the establishment of the Royal Institution in which Michael Faraday found the opportunity for his work.

Only a hundred miles west of here, in Albany, N. Y., another pioneer, Joseph Henry, carried out his early experiments in electromagnetic induction.

Professor Elihu Thomson, an earlier Faraday Medalist, spent many of the most productive years of his life in Lynn, Mass., only a hundred miles east of here. He was one of the most prolific of the pioneers in applying to the generation, utilization, and measurement of the electric current the principles of electromagnetic induction established by Faraday. Furthermore, I am sure it was Professor Thomson's influence, more than that of any other, upon his one-time pupil, later assistant, and, still later, chief, Doctor E. W. Rice, which was responsible for the foundation and active support of our Research Laboratory.

Finally, as one more factor connecting this locality with this event, my own birthplace is only a little over fifty miles from here.

But, if the location

suggests geographical relations, the occasion emphasizes their unimportance. This award by a British institution to an American is one more bit of evidence of the fact that science knows no national boundary lines.

Tribute to Laboratory Associates

It is in a spirit of deep humility, so far as my own contribution is concerned, that I accept the honor conferred upon me by The Institution of Electrical Engineers in giving me this medal and adding my name to the illustrious group of Faraday Medalists who have preceded me. I must accept it not as a personal tribute but rather as a tribute to a splendid group of workers of which, for 33 years, I have been so fortunate as to be a member.

That group was organized by Doctor Willis R. Whitney. By precept and example, he succeeded in bringing about such close co-operation that it is difficult, if not impossible, for me or any other member of that group to point to any development brought to anything like full fruition, which he could call exclusively his own. I take this opportunity to acknowledge the inspiration and generous help which I have received from Doctor Whitney and from my associates.

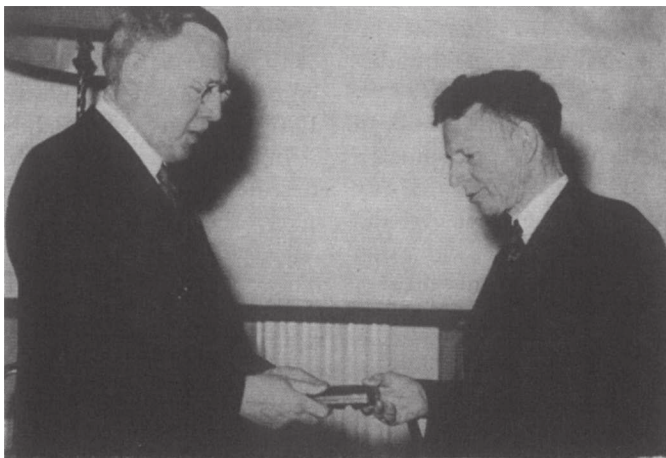
The Electrical Industry's Debt to Faraday

And also I feel that I truly owe an acknowledgment to Michael Faraday, for his fundamental researches were an effective stimulus to the conception of our laboratory. Not only can the origin of many General Electric products be traced directly to his work—such as our generators and transformers, which are the engineering derivatives of his classic discovery of electromagnetic induction—but, since economic generation and distribution of electric power have made possible the development of our great electrical industry, it may truly be said that our company owes its existence, as part of that industry, to Faraday's experiments.

It was the clear recognition of that fact by Doctor E. W. Rice and his associates that led to the foundation of our laboratory, in the hope, as Doctor Rice expressed it, that it might result in the establishment of new facts and principles which could serve as the basis for new things to be made in our factories.

As one studies Faraday's work, one is impressed, first, by the magnitude and diversity of the contributions he made to science, and second, by the simple equipment with which he achieved such epoch-making results. When Helmholtz visited him

Faraday Medal being presented to Doctor Coolidge by IEE Honorary Secretary Dunn



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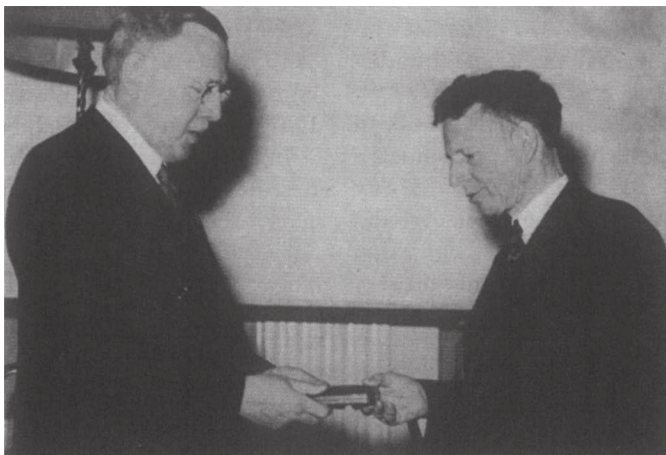
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Faraday Medal being presented to Doctor Coolidge by IEE Honorary Secretary Dunn



toward the close of his life and inspected his laboratory, he wrote in astonishment about the few pieces of copper wire and iron bars which had sufficed for the most far-reaching discoveries.

I think that the director of any modern research laboratory would hate to compare the output of his laboratory per dollar spent for either equipment or salaries with that of Faraday's laboratory in the Royal Institution. He would need several excuses. In the first place he would point out that he had not been able to find many young Faradays for his staff, and in the second place that much of the fundamental research work of today calls for complex and expensive equipment.

Such is the inevitable result of progress in research. In pioneering in a new field, simple tools may suffice, but, with the fundamental principles discovered, further work demands highly specialized facilities, for refined measurement, tests under extreme conditions, and development of special applications.

Extensions of Faraday's Research

This might be illustrated by many examples, taken from our recent work, of extensions of research along trails first opened by Faraday.

He recognized the need, in electromagnetic apparatus, of copper, insulation, and iron. With reference to the first of these, we have found it necessary to do much metallurgical research on copper. We have learned that we must free it of any oxide along grain boundaries if it is ever to be heated in a reducing atmosphere. Or, if it is to be stressed at elevated temperature, we may have to add silver to raise its equicohesive temperature and so prevent brittle fracture.

For primary insulation it has often been desirable first to enamel wire and then to wrap it with cotton or silk. Recent work has resulted in an enamel derived from polymerized vinyl acetate which is so adherent and so elastic that no other covering is needed, and so the space-factor is improved.

For secondary liquid insulation, non-inflammable pyranol has been developed, to be used in place of oil.

Recently we have become actively interested in the insulating properties of certain gases, notably the chlorine and fluorine derivatives of the methane hydrocarbon series. In the case of a new million-volt transformer-type X-ray outfit, 100 pounds of one of these compressed gases is furnishing insulation equivalent to that of 12,000 pounds of the liquid oil ordinarily used in transformers.

Research on transformer steel has been carried on continuously ever since our laboratory was started, and, as a result, magnetic losses have been reduced to less than one-fourth of what they were. Recent work has shown that, through the best amount of cold rolling, long narrow strips of steel may be produced having maximum permeability in the direction of their length, and that these, when preformed and annealed, can be wound around the primary and secondary coils to form the core of a transformer which for the same electrical performance is better mechanically, calls for less hand labor, and is some 40 per cent lighter in weight than its predecessors.

Faraday made many ferrous alloys and studied their physical properties. As ferrous alloys stronger at high temperature would make possible the attainment of higher economies in power production with both the steam and mercury processes, we are making many experimental alloy steels and testing them under sustained load at elevated temperatures. In this work special attention is paid to creep rate and to the determination of the equicohesive temperature range.

Some of our steel work has been in search of alloys having the same heat expansion as special glasses, to permit their being sealed together for the construction of vacuum tubes of various kinds and for other uses.

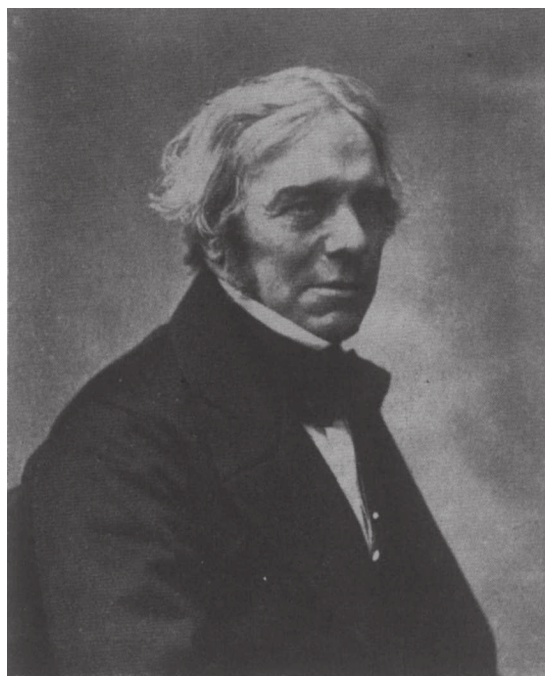
Much of our alloy work, both ferrous and non-ferrous, has been greatly facilitated by the pressed-powder method, with which we first became acquainted through the development of ductile tungsten

and ductile molybdenum, and later carbonyl.

Faraday studied the inactive or passive state of iron. We have recently been studying this in connection with the corrosion of stainless steel.

Faraday was interested in permanent magnets, both natural and artificial. We have been quite active in this field and, as a result, have seen the strength of permanent magnets gradually increased during the last 30 years some eight- or tenfold. The latest cast Alnico magnets consist of an alloy so hard that it cannot be machined. This would make the construction of small magnets of this material so expensive as to limit their use appreciably. We have recently found, however, that they can be made just as good, and for certain shapes much more cheaply, from pressed powder.

We are still actively interested in the sparks and arc-discharges with which Faraday worked. Only the dimensions have changed. Our latest 10,000,000-volt im-



Michael Faraday

Photograph reproduced from *The Telegraphic Journal and Electrical Review*, London, July 15, 1877

pulse generator produces sparks 30 feet long, while another high-current impulse generator delivers a quarter of a million amperes—more current than has ever been measured in a lightning stroke.

Arc characteristics are being studied in various gases and at pressures up to more than a thousand atmospheres. At moderate pressures, arc discharges in neon and in mercury vapor are being studied as light sources, while the low-temperature mercury arc has been coupled with a phosphor to transform the ultraviolet radiation into visible light, and so to increase the light output.

In radio research and in television, we are continuing Faraday's work on electromagnetic action at a distance. The principles are those discovered by him and formulated by Maxwell, but the distances have outgrown both the laboratory and the earth.

Faraday's leadership is a never-failing inspiration. To follow in his footsteps is a privilege indeed. To have succeeded in pressing a little farther along the paths he pointed out brings a satisfaction which itself sufficiently rewards the effort.